

CLAIMS

What is claimed is:

- 1 1. An integrated tone detection processor for discriminating between tone
2 and voice signals and determining the tones, the integrated tone detection processor
3 comprising:
 - 4 a semiconductor integrated circuit including,
 - 5 at least one signal processing unit to perform tone detection; and
 - 6 a processor readable storage means to store signal processing
 - 7 instructions for execution by the at least one signal processing unit to:
 - 8 perform automatic gain control (AGC) to normalize the power of
 - 9 the tone or voice signal;
 - 10 determine the energy of the tone or voice signals at specific
 - 11 frequencies utilizing a Goertzel Filter process which implements a plurality of Goertzel
 - 12 filters;
 - 13 determine whether or not a tone is present; and
 - 14 if a tone exists, determine what type of tone.
- 1 2. The integrated tone detection processor of claim 1, wherein determining
2 what type of tone includes determining whether the tone is one of a dial tone, a busy
3 tone, a fast busy tone, a ringing tone, or a fax tone.
- 1 3. The integrated tone detection processor of claim 1, wherein, Goertzel
2 filters compute the energy levels of tone or voice signals at 16 specific frequencies.
- 1 4. The integrated tone detection processor of claim 3, wherein four signal
2 processing units execute Goertzel filters, simultaneously.
- 1 5. The integrated tone detection processor of claim 1, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, determine two maximum energy levels of the tone or voice signal and their

4 associated frequencies, respectively, utilizing Goertzel filters.

1 6. The integrated tone detection processor of claim 5, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, based upon the two maximum energy levels of the tone signal and the
4 associated frequencies of the tone signal, discriminate whether the tone is a single tone,
5 a dual tone, silence, or another type of tone.

1 7. The integrated tone detection processor of claim 6, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, if the tone was discriminated as a single tone or dual tone, determine the tone
4 by identifying the tone in a user defined dictionary of tones.

1 8. The integrated tone detection processor of claim 7, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, update a state to TONE ON.

1 9. The integrated tone detection processor of claim 7, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, determine if a next tone is the same as the tone identified in the user defined
4 dictionary and, if so, increment a TONE ON counter.

1 10. The integrated tone detection processor of claim 9, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, when the next tone is not the same as the tone identified in the user defined
4 dictionary,

5 determine if an OFF cadence value is defined; and
6 if so, set a state to TONE ON/OFF.

1 11. The integrated tone detection processor of claim 9, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, when the next tone is not the same as the tone identified in the user defined

4 dictionary,
5 determine if an OFF cadence value is defined; and
6 if not, determine whether the tone identified in the user defined
7 dictionary satisfies an ON cadence value; and
8 if so, declare the tone.

1 12. The integrated tone detection processor of claim 10, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, increment a TONE OFF counter if a subsequent tone or voice signal includes
4 silence.

1 13. The integrated tone detection processor of claim 10, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, if a subsequent tone or voice signal does not include silence,

4 determine if the tone identified in the dictionary satisfies an ON cadence value
5 and an OFF cadence value; and
6 if so, declare a tone.

1 14. A method for discriminating between tone and voice signals and
2 determining the tones, the method comprising:
3 performing automatic gain control (AGC) to normalize the power of the tone or
4 voice signal;
5 determining the energy of the tone or voice signals at specific
6 frequencies utilizing a Goertzel Filter process which implements a plurality of Goertzel
7 filters;
8 determining whether or not a tone is present; and
9 if a tone exists, determining what type of tone.

1 15. The method of claim 14, wherein determining what type of tone includes
2 determining whether the tone is one of a dial tone, a busy tone, a fast busy tone, a
3 ringing tone, or a fax tone.

1 16. The method of claim 14, wherein, Goertzel filters compute the energy
2 levels of tone or voice signals at 16 specific frequencies.

1 17. The method of claim 16, wherein four signal processing units execute
2 Goertzel filters, simultaneously.

1 18. The method of claim 14, further comprising, determining two maximum
2 energy levels of the tone or voice signal and their associated frequencies, respectively,
3 utilizing Goertzel filters.

1 19. The method of claim 18, wherein based upon the two maximum energy
2 levels of the tone signal and the associated frequencies of the tone signal, further
3 comprising, discriminating whether the tone is a single tone, a dual tone, silence, or
4 another type of tone.

1 20. The method of claim 19, wherein if the tone was discriminated as a single
2 tone or dual tone, further comprising, determining the tone by identifying the tone in a
3 user defined dictionary of tones.

1 21. The method of claim 20, further comprising, updating a state to TONE
2 ON.

1 22. The method of claim 20, further comprising, determining if a next tone is
2 the same as the tone identified in the user defined dictionary and, if so, incrementing a
3 TONE ON counter.

1 23. The method of claim 22, further comprising, when the next tone is not the
2 same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if so, setting a state to TONE ON/OFF.

1 24. The method of claim 22, further comprising, when the next tone is not the
2 same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if not, determining whether the tone identified in the user defined
5 dictionary satisfies an ON cadence value; and
6 if so, declaring the tone.

1 25. The method of claim 23, further comprising, incrementing a TONE OFF
2 counter if a subsequent tone or voice signal includes silence.

1 26. The method of claim 23, further comprising, if a subsequent tone or voice
2 signal does not include silence,
3 determining if the tone identified in the dictionary satisfies an ON cadence
4 value and an OFF cadence value; and
5 if so, declaring a tone.

1 27. An integrated tone detection processor for discriminating between tone
2 and voice signals and determining the tones, the integrated tone detection processor
3 comprising:

4 a semiconductor integrated circuit including,
5 at least one signal processing unit to perform tone detection; and
6 a processor readable storage means to store signal processing
7 instructions for execution by the at least one signal processing unit to:
8 perform automatic gain control (AGC) to normalize the power of the tone or
9 voice signal;
10 filter the tone or voice signal utilizing an elliptical Infinite Impulse Response
11 (IIR) Filter to obtain a filtered tone or voice signal;
12 determine the energy of the tone or voice signal and the energy of the filtered
13 tone or voice signal;
14 decide whether a tone is present based upon comparing the energy of the
15 filtered tone or voice signal to the energy of the unfiltered tone or voice signal;
16 if a tone exists, determine what type of tone; and

17 if the tone is a modem tone or an echo cancellation (EC) disable tone,
18 provide further modem tone processing.

1 28. The integrated tone detection processor of claim 27, wherein determining
2 what type of tone includes determining whether the tone is one of a dial tone, a busy
3 tone, a fast busy tone, a ringing tone, a fax tone, or a modem tone.

1 29. The integrated tone detection processor of claim 27, wherein four signal
2 processing units execute the elliptical IIR filter, simultaneously.

1 30. The integrated tone detection processor of claim 27, wherein if a fax tone
2 is detected, voice processing is disabled and a data by-pass for fax processing is
3 provided.

1 31. The integrated tone detection processor of claim 27, wherein the modem
2 tone or an echo cancellation (EC) disable tone to be detected includes a tone operating
3 at 2100 Hz.

1 32. The integrated tone detection processor of claim 27, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 provide further modem tone processing, distinguish modem tones and echo cancellation
4 disable tones from other tones.

1 33. The integrated tone detection processor of claim 32, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish modem tones and echo cancellation disable tones from other tones,
4 determine phase reversals that are characteristic of modem tones and echo cancellation
5 disable tones.

1 34. The integrated tone detection processor of claim 33, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 determine phase reversals, locate a negative spike followed by positive spike in a

4 difference function of the filtered tone signal from the unfiltered tone signal.

1 35. The integrated tone detection processor of claim 34, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit
3 to, declare a modem or echo cancellation disable tone if the phase reversal occurs and
4 disable echo cancellation.

1 36. The integrated tone detection processor of claim 32, further comprising a
2 further fax tone processing module, and wherein the signal processing instructions
3 further for execution by the at least one signal processing unit to, distinguish Fax V.21
4 tones from other tones.

1 37. The integrated tone detection processor of claim 36, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, mix a digitized input tone corresponding to a tone to be
4 detected as a Fax V.21 tone with a stored copy of a carrier frequency of a Fax V.21
5 tone to demodulate the input tone.

1 38. The integrated tone detection processor of claim 37, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, pass the demodulated input tone through a lowpass filter to
4 remove high frequency noise content.

1 39. The integrated tone detection processor of claim 37, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, perform phase detection to recover an original modulated
4 input tone.

1 40. The integrated tone detection processor of claim 39, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, pass the original modulated input tone through a lowpass
4 filter to prevent aliasing.

1 41. The integrated tone detection processor of claim 39, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, reduce a sample rate of the original modulated input tone.

1 42. The integrated tone detection processor of claim 41, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 distinguish Fax V.21 tones, count codewords of the original modulated input tone and
4 if a pattern '7E' is seen three consecutive times, then a Fax V.21 tone is declared as
5 present.

1 43. A method for discriminating between tone and voice signals and
2 determining the tones, the method comprising:

3 performing automatic gain control (AGC) to normalize the power of the tone or
4 voice signal;

5 filtering the tone or voice signal utilizing an elliptical Infinite Impulse Response
6 (IIR) Filter to obtain a filtered tone or voice signal;

7 determining the energy of the tone or voice signal and the energy of the filtered
8 tone or voice signal;

9 deciding whether a tone is present based upon comparing the energy of the
10 filtered tone or voice signal to the energy of the unfiltered tone or voice signal;

11 if a tone exists, determining what type of tone; and

12 if the tone is a modem tone or an echo cancellation (EC) disable tone,
13 providing further modem tone processing.

1 44. The method of claim 43, wherein determining what type of tone includes
2 determining whether the tone is one of a dial tone, a busy tone, a fast busy tone, a
3 ringing tone, a fax tone, or a modem tone.

1 45. The method of claim 43, wherein four signal processing units execute the
2 elliptical IIR filter, simultaneously.

1 46. The method of claim 43, wherein if a fax tone is detected, voice
2 processing is disabled and a data by-pass for fax processing is provided.

1 47. The method of claim 43, wherein the modem tone or an echo cancellation
2 (EC) disable tone to be detected includes a tone operating at 2100 Hz.

1 48. The method of claim 43, wherein providing further modem tone
2 processing includes distinguishing modem tones and echo cancellation disable tones
3 from other tones.

1 49. The method of claim 48, wherein distinguishing modem tones and echo
2 cancellation disable tones from other tones includes determining phase reversals that
3 are characteristic of modem tones and echo cancellation disable tones.

1 50. The method of claim 49, wherein determining phase reversals includes
2 locating a negative spike followed by positive spike in a difference function of the
3 filtered tone signal from the unfiltered tone signal.

1 51. The method of claim 50, further comprising, declaring a modem or echo
2 cancellation disable tone if the phase reversal occurs and disabling echo cancellation.

1 52. The method of claim 48, further comprising, distinguishing Fax V.21
2 tones from other tones.

1 53. The method of claim 52, wherein distinguishing Fax V.21 tones includes
2 mixing a digitized input tone corresponding to a tone to be detected as a Fax V.21 tone
3 with a stored copy of a carrier frequency of a Fax V.21 tone to demodulate the input
4 tone.

1 54. The method of claim 53, further comprising, passing the demodulated
2 input tone through a lowpass filter to remove high frequency noise content.

1 55. The method of claim 53, wherein distinguishing Fax V.21 tones includes
2 performing phase detection to recover an original modulated input tone.

1 56. The method of claim 55, further comprising, passing the original
2 modulated input tone through a lowpass filter to prevent aliasing.

1 57. The method of claim 55, wherein distinguishing Fax V.21 tones includes
2 reducing a sample rate of the original modulated input tone.

1 58. The method of claim 57, wherein distinguishing Fax V.21 tones includes
2 counting the codewords of the original modulated input tone and if a pattern '7E' is seen
3 three consecutive times, then a Fax V.21 tone is declared as present.

1 59. An apparatus comprising:
2 a tone detection processor including at least one signal processing unit to
3 perform tone detection; and
4 a storage device to store signal processing instructions for execution by the at
5 least one signal processing unit to:
6 perform automatic gain control (AGC) to normalize the power of a tone
7 or voice signal;
8 determine the energy of the tone or voice signals at specific frequencies
9 utilizing a Goertzel Filter process which implements a plurality of Goertzel filters;
10 determine whether or not a tone is present; and
11 if a tone exists, determine what type of tone.

1 60. The apparatus of claim 59, wherein determining what type of tone
2 includes determining whether the tone is one of a dial tone, a busy tone, a fast busy
3 tone, a ringing tone, or a fax tone.

1 61. The apparatus of claim 59, wherein, Goertzel filters compute the energy
2 levels of tone or voice signals at 16 specific frequencies.

1 62. The apparatus of claim 61, wherein four signal processing units execute
2 Goertzel filters, simultaneously.

1 63. The apparatus of claim 59, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, determine two
3 maximum energy levels of the tone or voice signal and their associated frequencies,
4 respectively, utilizing Goertzel filters.

1 64. The apparatus of claim 63, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, based upon the
3 two maximum energy levels of the tone signal and the associated frequencies of the
4 tone signal, discriminate whether the tone is a single tone, a dual tone, silence, or
5 another type of tone.

1 65. The apparatus of claim 64, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, if the tone was
3 discriminated as a single tone or dual tone, determine the tone by identifying the tone in
4 a user defined dictionary of tones.

1 66. The apparatus of claim 65, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, update a state
3 to TONE ON.

1 67. The apparatus of claim 65, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, determine if a
3 next tone is the same as the tone identified in the user defined dictionary and, if so,
4 increment a TONE ON counter.

1 68. The apparatus of claim 67, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, when the next
3 tone is not the same as the tone identified in the user defined dictionary,

4 determine if an OFF cadence value is defined; and
5 if so, set a state to TONE ON/OFF.

1 69. The apparatus of claim 67, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, when the next
3 tone is not the same as the tone identified in the user defined dictionary,
4 determine if an OFF cadence value is defined; and
5 if not, determine whether the tone identified in the user defined
6 dictionary satisfies an ON cadence value; and
7 if so, declare the tone.

1 70. The apparatus of claim 68, wherein the signal processing instructions
2 further for execution by the at least one signal processing unit to further, increment a
3 TONE OFF counter if a subsequent tone or voice signal includes silence.

1 71. The integrated tone detection processor of claim 68, wherein the signal
2 processing instructions further for execution by the at least one signal processing unit to
3 further, if a subsequent tone or voice signal does not include silence,
4 determine if the tone identified in the dictionary satisfies an ON cadence value
5 and an OFF cadence value; and
6 if so, declare a tone.

1 72. A method comprising:
2 performing automatic gain control (AGC) to normalize the power of the tone or
3 voice signal;
4 determining the energy of tone or voice signals at specific frequencies utilizing
5 a Goertzel Filter process which implements a plurality of Goertzel filters wherein at
6 least four signal processing units execute the Goertzel filters, simultaneously;
7 determining whether or not a tone is present; and
8 if a tone exists, determining what type of tone.

1 73. The method of claim 72, wherein determining what type of tone includes

2 determining whether the tone is one of a dial tone, a busy tone, a fast busy tone, a
3 ringing tone, or a fax tone.

1 74. The method of claim 72, wherein, Goertzel filters compute the energy
2 levels of tone or voice signals at 16 specific frequencies.

1 75. The method of claim 72, further comprising, determining two maximum
2 energy levels of the tone or voice signal and their associated frequencies, respectively,
3 utilizing Goertzel filters.

1 76. The method of claim 75, wherein based upon the two maximum energy
2 levels of the tone signal and the associated frequencies of the tone signal, further
3 comprising, discriminating whether the tone is a single tone, a dual tone, silence, or
4 another type of tone.

1 77. The method of claim 76, wherein if the tone was discriminated as a single
2 tone or dual tone, further comprising, determining the tone by identifying the tone in a
3 user defined dictionary of tones.

1 78. The method of claim 76, further comprising, updating a state to TONE
2 ON.

1 79. The method of claim 76, further comprising, determining if a next tone is
2 the same as the tone identified in the user defined dictionary and, if so, incrementing a
3 TONE ON counter.

1 80. The method of claim 79, further comprising, when the next tone is not the
2 same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if so, setting a state to TONE ON/OFF.

1 81. The method of claim 79, further comprising, when the next tone is not the

2 same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if not, determining whether the tone identified in the user defined
5 dictionary satisfies an ON cadence value; and
6 if so, declaring the tone.

1 82. The method of claim 80, further comprising, incrementing a TONE OFF
2 counter if a subsequent tone or voice signal includes silence.

1 83. The method of claim 80, further comprising, if a subsequent tone or voice
2 signal does not include silence,
3 determining if the tone identified in the dictionary satisfies an ON cadence
4 value and an OFF cadence value; and
5 if so, declaring a tone.

1 84. A machine-readable medium having stored thereon instructions, which
2 when executed by a machine, causes the machine to perform operations comprising:
3 performing automatic gain control (AGC) to normalize the power of the tone or
4 voice signal;
5 determining the energy of tone or voice signals at specific frequencies utilizing
6 a Goertzel Filter process which implements a plurality of Goertzel filters;
7 determining whether or not a tone is present; and
8 if a tone exists, determining what type of tone.

1 85. The machine-readable medium of claim 84, wherein determining what
2 type of tone includes determining whether the tone is one of a dial tone, a busy tone, a
3 fast busy tone, a ringing tone, or a fax tone.

1 86. The machine-readable medium of claim 84, wherein, Goertzel filters
2 compute the energy levels of tone or voice signals at 16 specific frequencies.

1 87. The machine-readable medium of claim 86, wherein four signal

2 processing units execute Goertzel filters, simultaneously.

1 88. The machine-readable medium of claim 84, further comprising,
2 determining two maximum energy levels of the tone or voice signal and their
3 associated frequencies, respectively, utilizing Goertzel filters.

1 89. The machine-readable medium of claim 88, wherein based upon the two
2 maximum energy levels of the tone signal and the associated frequencies of the tone
3 signal, further comprising, discriminating whether the tone is a single tone, a dual tone,
4 silence, or another type of tone.

1 90. The machine-readable medium of claim 89, wherein if the tone was
2 discriminated as a single tone or dual tone, further comprising, determining the tone by
3 identifying the tone in a user defined dictionary of tones.

1 91. The machine-readable medium of claim 90, further comprising, updating
2 a state to TONE ON.

1 92. The machine-readable medium of claim 90, further comprising,
2 determining if a next tone is the same as the tone identified in the user defined
3 dictionary and, if so, incrementing a TONE ON counter.

1 93. The machine-readable medium of claim 92, further comprising, when the
2 next tone is not the same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if so, setting a state to TONE ON/OFF.

1 94. The machine-readable medium of claim 92, further comprising, when the
2 next tone is not the same as the tone identified in the user defined dictionary,
3 determining if an OFF cadence value is defined; and
4 if not, determining whether the tone identified in the user defined
5 dictionary satisfies an ON cadence value; and

6 if so, declaring the tone.

1 95. The machine-readable medium of claim 93, further comprising,
2 incrementing a TONE OFF counter if a subsequent tone or voice signal includes
3 silence.

1 96. The machine-readable medium of claim 93, further comprising, if a
2 subsequent tone or voice signal does not include silence,
3 determining if the tone identified in the dictionary satisfies an ON cadence
4 value and an OFF cadence value; and
5 if so, declaring a tone.

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